Module 3: Strings and Input/Output

Topics:
• Strings and their methods
• Printing to standard output
• Reading from standard input

Readings: ThinkP 8, 10
Practice: Self study exercises
Strings in Python: combining strings in interesting ways

```python
s = "Great"
t = "CS116"
u = s + t
v = s + "!!! " + t
w = s * 3
x = 2 * t
y = 'single quote works too'
z = 'strings can contain quotes" too'
```
Overloading of *

The following are all valid contracts of *:

* : Int Int → Int
* : Int Float → Float
* : Float Int → Float
* : Float Float → Float
* : Int Str → Str
* : Str Int → Str

What contracts apply to +? To -?
Other string operations

• Contains substring: \texttt{s in t}
  
  Returns \texttt{True} if the string \texttt{s} appears as a substring in the string \texttt{t}

  \begin{align*}
  \text{"astro" in "catastrophe"} & \Rightarrow \text{True} \\
  \text{"car" in "catastrophe"} & \Rightarrow \text{False} \\
  \text{"" in "catastrophe"} & \Rightarrow \text{True}
  \end{align*}

• String length: \texttt{len(s)}
  
  Returns the number of characters in string \texttt{s}

  \begin{align*}
  \text{len(""')} & \Rightarrow 0, \\
  \text{len("Billy goats gruff!")} & \Rightarrow 18
  \end{align*}
Extracting substrings

- \texttt{s[i:j]} returns the substring from string \texttt{s}, containing all the characters in positions \texttt{i}, \texttt{i+1}, \texttt{i+2}, \ldots, \texttt{j-1}
- \texttt{s[i:j:k]} steps by \texttt{k}, instead of 1
- \texttt{s[k]} returns a string containing the character at position \texttt{k}
- Like Racket, strings in Python start from position 0

Suppose \texttt{s = "abcde"}, what strings are returned?
- \texttt{s[2:4]}, \texttt{s[0:5]}, \texttt{s[2:3]}, \texttt{s[3:3]}, \texttt{s[2:20]}, \texttt{s[8:]}
- \texttt{s[2:]}, \texttt{s[:3]}
- \texttt{s[1:5:2]}, \texttt{s[2::3]}, \texttt{s[::-1]}
- \texttt{s[4]}, \texttt{s[-1]}
Strings are immutable

We cannot change the individual characters in a string \( s \)

\[
s = "abcde"
\]

\[
s[3] = "X" 
\]
causes an error

but

\[
s = s[:3] + "X" + s[4:]
\]
returns a new string "abcXe" and assigns it to \( s \)

Note that \texttt{Int}, \texttt{Float}, \texttt{Str}, and \texttt{Bool} values are also immutable.
Methods in Python

• `str` is the name of a class in Python
• By convention, `Str` (capital S) is used in contracts
• Like the `math` module, `str` contains many functions, in its case to process string values
• To use the functions in `str`:
  ```python
  s = "hi"
  s.upper() ⇒ "HI"
  ```
• Note that none of the string methods modify the string itself
Partial listing of string methods

```python
>>> dir("abc")
[ ..., 'capitalize', 'center', 'count',
  'endswith', 'find', 'format',
  'index', 'isalnum', 'isalpha',
  'isdigit', 'islower', 'isspace',
  'isupper', 'join', 'lower',
  'lstrip', 'partition', 'replace',
  'rfind', 'split', 'startswith',
  'strip', 'swapcase', 'translate',
  'upper', ..., ]
```
Using string methods

```python
s = 'abcde 1 2  3 ab   
```

What do the following calls return?

```python
s.find('a')
s.find('a',1)
s.startswith('abc')
s.count('a')
s.replace(' ','')
s.strip()
```
Getting more information about a **str** method

```python
>>> help ('''.isalpha)
S.isalpha() -> bool
```

Return True if all characters in S are alphabetic and there is at least one character in S, False otherwise.
Exercise

Write a Python function that consumes a non-empty first name, middle name (which might be empty), and a non-empty last name, and constructs a userid consisting of first letter of the first name, first letter of the middle name, and the last name. The userid must be in lower case, and no longer than 8 characters, so truncate the last name if necessary. For example,

userid("Harry", "James", "Potter") ⇒ "hjpotter"
userid("Ronald", "Bilius", "Weasley") ⇒ "rbweasle"
Recursive String definition and function template

A Python String is either

• "", or

• $s + t$, where $s$ and $t$ are strings, and $\text{len}(s)=1$.

def my_string_template(s):
    if s=="":
        # base case
    else:
        # ... $s[0]$ ... my_string_template(s[1:])
Recursion on Strings

Write a Python function \texttt{str\_score} that consumes a string \texttt{s}, and returns the score for \texttt{s}, where

- alphabetical characters are worth 1 point,
- digits are worth their numerical value, and
- any other character is worth 0.

For example,

\texttt{str\_score("CS 116") ⇒ 10}
Run the following program in the Definitions window. What do you see?

```python
def middle(a, b, c):
    largest = max(a, b, c)
    smallest = min(a, b, c)
    mid = (a+b+c) - largest - \smallest
    return mid

middle(10, 20, 30)
middle(0, 10, -10)
middle(-1, -3, -2)
```
Python output:
printing information to the screen

```python
x = 20
print(x)
print(x+5)
y = "dog"
print(y)
z = 42.8
print(z)
print(x,y,z)
```
More on *print* function

- Has an effect
  - printing to "standard output" - the screen
- Does not return a value
  - technically, we say it returns *None*
Displaying values in Python programs

• Interactions window, for variable x:
  ```
  x
  print(x)
  ```
• Result *usually* looks the same (except for strings), but they are different
• Difference is obvious in Definitions window
→ Need to use `print` in our programs to see results as the program is running
New: Functions do not always need to return values

• We can write a function which only prints data
• If a function does not include a `return val` statement, then the returned value (and type) is `None`
• The purpose statement does not need to include "Returns None" as this will be included in the contract.
Design recipe changes:
If a function includes `print` statements

• Include a description of what is printed in the `Purpose` statement

• Add a new section: an `Effects` statement (immediately after the purpose) to briefly indicate a value is printed

• `Examples` should include a description of the actual values printed for that input

It may also include a `return` statement.
Example: Write a function that prints a string three times – once per line

```python
def print_it_three_times(s):
    '''prints s on three lines, once per line
    Effects: Prints to the screen

    print_it_three_times: Str -> None

    Example: Calling print_it_three_times("a")
    prints a once on each of three lines.
    '''
    print(s)
    print(s)
    print(s)
```

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Testing Screen Output

• Our check module contains functions for two different approaches for testing screen output:
  – set_screen – sets things up for the tester to check screen output
  – set_print_exact – will check exactly whether screen output matches the expected screen output
• Unless told otherwise on an assignment, you can choose the testing approach that you prefer.
• In both cases, the screen output testing function must be called before the function to check the return value (within or expect).
Testing Screen Output: `set_print_exact`

- Include a string for each line of expected screen output:
  ```python
  check.set_print_exact("CS 116", "CS 116", "CS 116")
  ```
- Followed by appropriate `check` function to test value returned by the function (even if it is `None`)
- When `expect/within` runs, in addition to comparing expected and actual return values, the strings in `set_print_exact` will be compared to the actual strings printed by the function, line-by-line.
import check

def print_it_three_times(s):
    print(s)
    print(s)
    print(s)

# Q6 Test 1: a short string - "CS 116"
check.set_print_exact("CS 116", "CS 116", "CS 116")
check.expect("p3T1",
    print_it_three_times("CS 116") ,None)

There is no return, so function returns None. This value is passed to check.expect to verify.
Test Output

p3T1: PASSED

None was correctly returned by our function.

p3T1 - print output: PASSED

-----

The strings passed to set_print_exact are exactly the strings printed by the function.
A failed test

def print_it_three_times(s): # Incorrect
    print(s)
    print(s)
    print(s)
-----

None was correctly returned by our function.

p3T1: PASSED

p3T1 - print output: FAILED; expected
CS 116
CS 116
CS 116
saw
CS 116
CS 116

The function did not print the expected strings, so an informative message is printed.
Testing Screen Output: `set_screen`

- Give a description of expected screen output:
  ```python
  check.set_screen(
      "CS 116 on three lines"
  )
  ```
- Followed by appropriate `check` function to test value returned by the function (even if it is `None`)
- Test will print screen output along with your description of what the screen output should be.
- **You must then compare the two.**
- **No comparisons of the actual and expected string outputs are made by the `check` module.**
- Useful if the output is very complicated and long.
import check

def print_it_three_times(s):
    print(s)
    print(s)
    print(s)

# Q6 Test 1: a short string – "CS 116"
check.set_screen("CS 116 on three lines")
check.expect("Q6T1",
    print_it_three_times("CS 116"), None)

There is no return, so function returns None. This value is passed to check.expect to verify.
Test Output

QT1 PASSED

-----

QT1 (expected screen output):
CS 116 on three lines

QT1 (actual screen output):
CS 116
CS 116
CS 116

You must examine your output to see if it matches what you expected.

None was correctly returned by our function.
Printing vs Returning

Complete the full design recipes for $f_1$ and $f_2$.

def $f_1(x)$:
    print($x+1$)

def $f_2(x)$:
    return $x+1$
Debugging your program with \texttt{print} statements

- If you have an error in your program, place \texttt{print} statements at points throughout your program to display values of variables.

- \textbf{IMPORTANT}: Remember to remove the \texttt{print} statements before submitting your code.

  – Your program may fail our tests, even if it returns the correct function values!!!
A new Python feature

- Python functions can use information received in three different ways –
  - Two ways we have seen in Racket:
    - Parameters
    - Global constants
  - A new way:
    - Entered via the keyboard
User Input to a Python Program

```python
user_input = input()
```
- Program stops
- Nothing happens until the user types at keyboard
- When user hits enter, a string containing all the characters before the return is returned by `input`
- The string value is used to initialize the variable `user_input`
- Program continues with new value of `user_input`
More on user input

• Alternate form (preferred):
  
  ```python
  user_input = input(prompt)
  ```

  e.g.

  ```python
  city = input("Enter hometown:")
  ```

• Prints the value of `prompt` before reading any characters

• Value returned by `input` is always a `str`
User Input and the Design Recipe

• When a function includes an input call, this must be described in the Purpose statement:
  – Describe what happens with the value entered by the user
  – Use parameter names in your description, where relevant

• It should also be mentioned (without the same detail) in the Effects statement.
def repeat_str():
    '''reads in a string s, and a number n, and
    prints s n times on one line
    Effects:
    * Two values are read in and
    * One string is printed
    repeat_str: None -> None
    Examples: If the user enters "abc" and 4
    when repeat_str() is called,
    "abcabcabcabc" is printed
    If the user enters "" and 100
    when repeat_str is called, "" is printed
    '''
A Simple Program using **input**

```python
def repeat_str():
    s = input("Enter string: ")
    t = input("Enter int>=0: ")
    n = int(t)
    print(n*s)
```
Testing With User Input

• Set the user inputs needed for the test in order.
• Always use strings for the input values.
• Include one string for each call to `input` that happens in your test:

```python
check.set_input("CS116","3")
```
• Follow with appropriate `check` function for value returned by the function
• Test function will automatically use these values (in order) when a value is expected from `input`
• You will be warned if the argument to `set_input` contains too few or too many values
Example: Test with User Input

```python
import check
def add_two_inputs():
    '''add_two_inputs: None -> Int'''
    x = int(input("Enter 1st integer: "))
    y = int(input("Enter 2nd integer: "))
    return x+y

# Test 1: two positive numbers
check.set_input("2","7")
check.expect("AddT1", add_two_inputs(), 9)
```
Example

Write the Python function `n_times` that reads a natural number `n` from the user via the keyboard, and prints out `n` once per line on `n` lines. The function returns `None`. 
More on strings: Formatting screen output

• We can print strings
  `print("my dog has fleas")`

• We can print integers
  `fleacount = 12`
  `print(fleacount)`

• We can even combine them
  `print("my dog has", fleacount, "fleas")`
  `print("my dog has " + str(fleacount) + " fleas")`
Creating formatted strings

The `format` method and placeholder `{}`

• We can describe the string we want to build, indicating where values should be inserted by using placeholders indicated by `{#}` inside the string

• Then supply the values to insert

```python
fleastring = "My dog has {0} fleas".format(fleacount)
print(fleastring)
```
The string you are building contains {#} and is followed by `.format(a_0, a_1, …, a_n)`

Uses the embedded {#} to show where a value should be inserted in the new string

The # indicates which of the `format` arguments (0 – n) should appear at that location of the string

s="Did {0} repay {1} ${2} from {0}'s pay?"
print(s.format("Tom", "Li", 20))
Examples

"I like {1}{0} {2}% of the time".format(116,"CS",500/6)
⇒ "I like CS116 83.33333333333333% of the time"

"I have taken {2}{0} and {2}{1}".format(115,116,"CS")
⇒ "I have taken CS115 and CS116."

"Temp is {0}C (or {1}F)".format(-10.0,(-10)*9/5+32)
⇒ "Temp is -10.0C (or 14.0F)"
Possible errors in formatting

• Incorrect number of values to insert

```python
>>> print("\{0\} \{1\} \{2\}\.format(42.0, 12))
IndexError: tuple index out of range
```
Printing on one line

- Recall that
  
  ```python
  print("this goes","on","one line")
  print("this on the next")
  print("and so on")
  ```

  goes on three separate lines

- However,
  
  ```python
  print("this goes","on","one line",end="",")
  print("and this on the same",end="")
  print(" and so on")
  ```

  all goes on one line (due to value of end argument)
Special Characters

• So, we know how to use `print` statements to put information on one line

• Can you use a single print statement to put information over multiple lines?
  – Yes, but we need a special character `\n`
  ```python
  print("one line\nanother\nand another ")
  ```
  – Despite taking 2 characters to type, it counts as one in string length
  ```python
  len("A\nB\nC\n") ⇒ 6
  ```
Goals of Module 03

• You should be comfortable the following in Python:
  – Strings and their methods
  – Printing to the screen
  – Reading from the keyboard